To a large extent such issues ultimately are settled in the marketplace; but we believe, nevertheless, that the Commission has a role to play in ensuring a smooth transition. In this manner, the television landscape can be radically transformed and improved for the better with a minimum of dislocation for all concerned. We urge the Commission to heed the experience of the past 50 years of television broadcasting and foster a smooth evolution to ATV.

NBC believes that this proceeding will elicit several clear criteria for any ATV system, based upon basic public interest considerations. Television broadcasters must be able to maintain their competitive position vis-a-vis other means of delivering video images to the home, or free service to the public of local broadcasting may become a second class service or disappear altogether. broadcasters should have the ability to choose to transmit higher quality television images and consumers should have the ability to choose to receive higher quality television images.

To accomplish this, any ATV system offered should be NTSC receiver compatible, and it should have the capacity for growth. That is, even though the short-term quality improvements offered by a system such as ACTV may be considerable, ultimately, as display technology improves and other technological advances are made, the ATV system in place should be adaptable to offer further enhancement at minimal cost with minimal displacement. Accordingly, spectrum must be preserved to permit transition to a system with greater signal enhancement in the future. Although the existing data are inadequate for an early decision on spectrum allocation, a major study of the VHF and UHF bands should be commenced as soon as practicably possible to determine how additional spectrum could be made available for ATV. Clearly, no spectrum should be made unavailable absent a comprehensive analysis of the present and future needs of broadcasting.

NBC's ACTV system is expected to provide a means for broadcasters and other video delivery services to deliver enhanced television signals to the public in the shortest possible time with the least dislocation in the industry. It will be able to be implemented within the existing 6-MHz channel allocation. It will be capable of providing images comparable to those that will be provided by other systems. It also will be compatible with the 140 million existing NTSC receivers. Moreover, the cost of a new ACTV wide-screen receiver very likely will be less than for other proposed systems.

NBC believes that at this early stage the Commission has an important role to play. As the guardian of the public interest, the Commission can ensure that the public is not left behind in the process, by ensuring NTSC compatibility and orderly spectrum planning so that local broadcasters, who provide free television service, can participate. The public will reap the greatest benefits if advanced television systems, as remarkable as is their performance, are introduced in an evolutionary process, not by cataclysm.

Respectfully submitted,

Howard Monderer

Howard Monderer
Vice President, Law, Washington

Molly Pauker

Molly Pauker
General Attorney

National Broadcasting Company, Inc.
1825 K Street, N.W., Suite 807
Washington, D.C. 20006

Consulting Engineers:
Stanley Baron
Managing Director, Technical Development

Martin H. Meaney
Director, Allocations Engineering

National Broadcasting Company, Inc.
30 Rockefeller Plaza
New York, New York 10112

November 18, 1987

A Single Channel, NTSC Compatible Widescreen EDTV System

M.A.Isnardi, J.S. Fuhrer, T.R. Smith, J.L. Koslov, B.J. Roeder, W.F. Wedam

David Sarnoff Research Center
Princeton, NJ, USA

ABSTRACT

This paper describes a proposal for a fully NTSC-compatible, single-channel signal system intended for the transmission of 5x3 EDTV images. The displayed image is free of NTSC artifacts and has in excess of 420 lines of resolution per picture height, both horizontally and vertically. The system can use standard 1125/2:1, 1050/2:1, or 525/1:1 HDTV signals as input. These wideband RGB signals are processed using a variety of techniques, combined with a new scheme for sending the side panels in a fully compatible manner.

The widescreen signal is first separated into various components, such as center panel luminance and color, high-frequency luminance detail, and vertical-temporal luminance detail. After appropriate three-dimensional prefiltering of these component signals, the high-frequency signals are modulated onto a new subcarrier and are subsequently hidden in spectral holes of the composite center signal. The low-frequency side panel information is time compressed into 1 μs on each side of the active picture.

Similar digital signal processing is needed in the receiver to recover the various components. The new, 5x3 EDTV receiver requires less than 1 megabyte of memory for signal processing. Its display can be either 525-line progressive scan or 1050-line interlace. Standard, existing television receivers will display the new signal as a standard NTSC picture virtually unimpaired.

Field test hardware for this system is under construction. Numerous HDTV test patterns, still images, and motion sequences have been computer processed and evaluated on HDTV and NTSC monitors.

The system can be augmented with even more resolution if additional spectrum is available in the future.

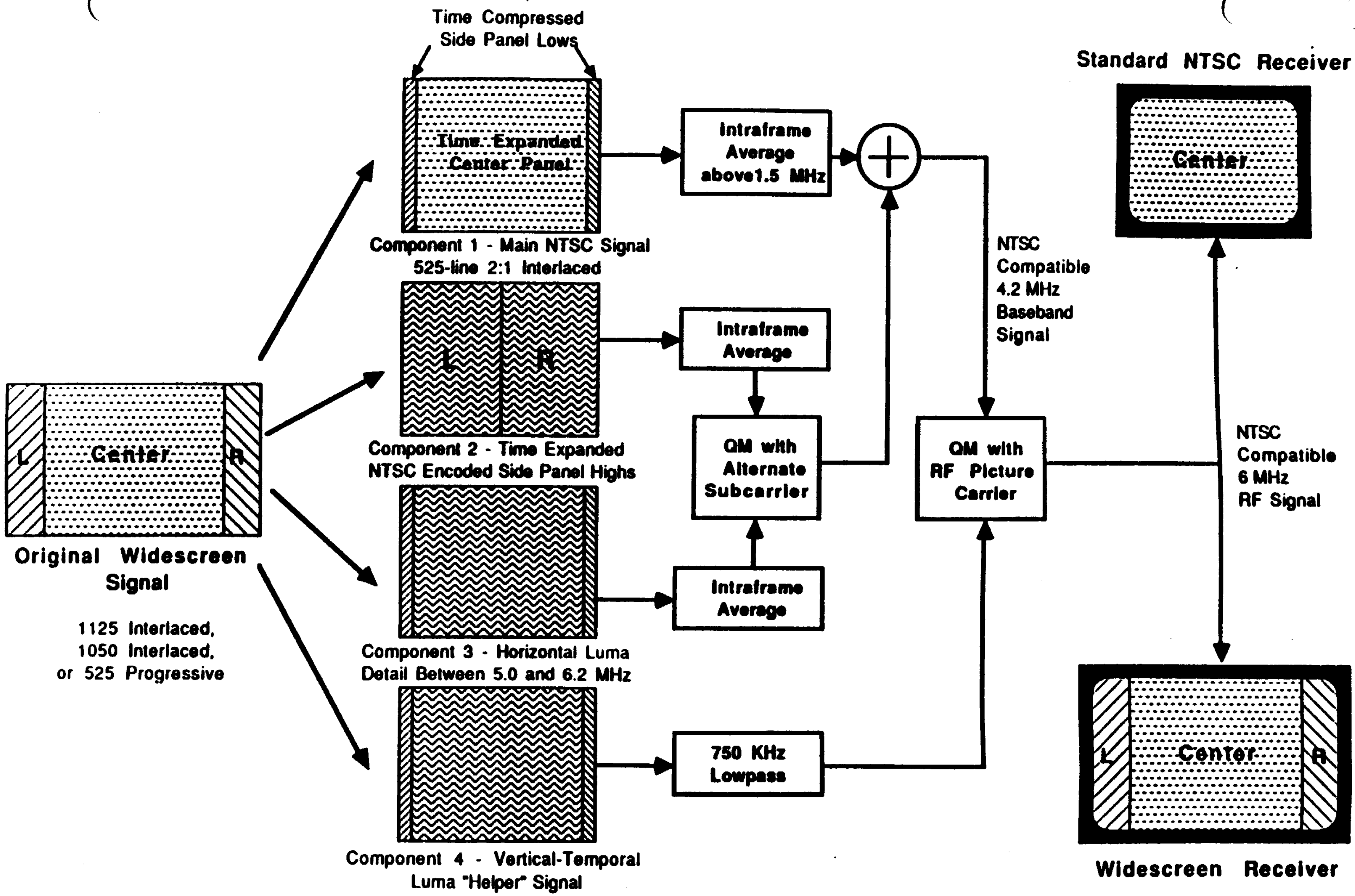

Fig. 1. Single Channel NTSC Compatible Widescreen EDTV System

INTRODUCTION

This paper describes a single-channel, NTSC-compatible widescreen system that provides extended spatio-temporal luminance detail. The encoded signal occupies a single 6-MHz television channel, and a standard NTSC receiver tuned to that channel displays a normal color picture with 4:3 aspect ratio. Because of special prefiltering, a standard receiver actually benefits by displaying a picture with reduced chroma/luma crosstalk. The widescreen receiver, tuned to the same RF channel, decodes the hidden side panel and luminance information and reconstructs the widescreen picture with enhanced detail.

SYSTEM OVERVIEW

In this section, we provide a brief overview of the single-channel NTSC-compatible widescreen EDTV system. Detailed descriptions of the processing algorithms and hardware implementation will appear in future publications.

The original widescreen signal may come from either an interlaced or progressively scanned high-definition source, with the latter being preferred. The widescreen aspect ratio is assumed to be 5:3, but the system can handle an even wider aspect ratio of 16:9 with only minor modifications.

The widescreen source signal is digitized and encoded into the following four components, shown in Fig. 1:

(1) a main 2:1 interlaced signal with 4:3 aspect ratio consisting of (a) the central 4:3 portion of the widescreen signal that has been time expanded to nearly the entire active line time, and (b) the side panel low horizontal frequencies that have been time compressed into the left and right horizontal overscan regions, where they are hidden from view in nearly all home receivers. Filter cutoffs are chosen to insure that the resulting luma bandwidth is no more than 4.2 MHz. This signal is color encoded in standard NTSC format. Luma and chroma are prefiltered using field combs to provide improved separation at both the NTSC and widescreen receivers.

(2) an auxiliary 2:1 interlaced signal consisting of side panel high horizontal frequencies that have been pre-combed, NTSC encoded, and time expanded to half the active line time. The time expansion reduces the horizontal bandwidth of this component to about 1.1 MHz. This component is spatially uncorrelated with the main signal, and special precautions must be taken to mask its visibility on standard NTSC receivers.

(3) an auxiliary 2:1 interlaced signal consisting of horizontal luminance detail between approximately 5.0 and 6.2 MHz. This band of frequencies is first shifted downward to the range 0.0 to 1.2 MHz. This component is mapped into 4:3 format, which spatially correlates it with the main signal and helps to mask its visibility on standard NTSC receivers.

(4) an auxiliary 2:1 interlaced "helper" signal consisting of vertical-temporal (V-T) luminance detail that would otherwise be lost in the down conversion to 525-line interlace. This component is mapped into 4:3 format, which spatially correlates it with the main signal and helps to mask its visibility on standard NTSC receivers. It is also bandlimited to 750 KHz. At the widescreen receiver, this signal helps to reconstruct missing lines and to reduce or eliminate line flicker artifacts.

IMPROVEMENTS OFFERED BY PROPOSED SYSTEM

The proposed widescreen EDTV system offers several noticeable improvements over a standard NTSC picture. A viewer making a side-by-side comparison of a standard NTSC receiver and a new widescreen receiver, tuned to the same channel, will notice the following improvements.

Of greatest significance is the *wider aspect ratio*, since this is a difference that the average viewer will notice immediately. At any viewing distance, the consumer sees a picture with the widescreen impact of film. An important selling point is that the widescreen receiver is curiously different from the standard receiver even when both sets are turned off!

At a normal viewing distance between three and five times the picture height, other improvements become apparent. The widescreen picture is *quieter*, virtually free from the interline flicker so common in NTSC sets. It is also *cleaner*, virtually free from crawling dots, hanging dots, and bizarre rainbow effects. The widescreen picture has noticeably *increased resolution* in both spatial dimensions. Line structure is not visible because of the increased line density. In moving portions of the picture, a startling improvement is the absence of the beat between moving horizontal edges and the scanning structure, an artifact so annoying in conventional NTSC.

SYSTEM ARTIFACTS

The improvements mentioned above do not come free -- they are achieved by *replacing* selected picture detail with what we believe is perceptually more important information. Because of the complex encoding process, the reconstructed widescreen signal is not completely free from artifacts, and research is currently focussed on reducing them as much as possible. The artifacts are caused by a combination of intraframe averaging, V-T filtering, and horizontally bandlimiting the "helper" signal. Static areas of the image exhibit slightly jagged diagonal edges, caused by intraframe averaging. Moving areas reveal several artifacts: (1) a slight loss of spatio-temporal resolution, caused by the V-T luma/chroma pre-filter, (2) a slight jitter, not unlike film, caused by intraframe averaging, and (3) a slight flicker along moving diagonal edges, caused by the bandlimited "helper" signal. All artifacts are more pronounced in the side panels.

CONCLUSIONS AND FUTURE RESEARCH

A new single channel NTSC compatible EDTV widescreen system was designed and simulated in software. An existing NTSC receiver displays the central 4:3 portion of the widescreen image with standard NTSC resolution and with little degradation caused by the modulation of auxiliary information within the channel. A widescreen receiver recovers the main and auxiliary signals and reconstructs a widescreen progressive scan picture with enhanced luminance detail.

Future research is aimed at reducing the static and motion artifacts and at analyzing the system's performance in the presence of channel noise and other degradations.

Components 1,2, and 3 are passed through a special time-variant V-T filter called an *intraframe averager* to eliminate V-T crosstalk between the main and auxiliary signals at the widescreen receiver. The main signal is intraframe averaged above 1.5 MHz, and the auxiliary signals are intraframe averaged over all horizontal frequencies. Components 2 and 3 are amplitude compressed in a nonlinear fashion, quadrature modulated on a phase-controlled subcarrier at 3.108 MHz, and added to component 1. The result is a 4.2 MHz baseband signal that is RF modulated into a standard 6 MHz NTSC channel. Component 4 is modulated in quadrature with the main RF picture carrier. [1]

When received on an existing NTSC receiver, only the central portion of the main signal is seen (the time compressed side panel lows will be completely hidden in the overscan regions in nearly all home receivers). Components 2 and 3 create a low-amplitude interference pattern that is not perceived at normal viewing distances and at normal levels of sharpness, contrast, and chroma saturation. Component 4 is removed completely on sets with synchronous detectors; on sets with envelope detectors, component 4 is processed but not perceived because it is correlated with the main signal.

A widescreen receiver recovers and equalizes components 1-4 and reconstructs the original widescreen progressive scan signal. Relative to NTSC, the reconstructed signal has left and right side panels with standard NTSC resolution and a central 4:3 portion with superior horizontal and vertical luminance detail in the stationary portions of the image.

COMPUTER SIMULATION

The entire system was simulated in FORTRAN on a VAX 8800 batch processor at the David Sarnoff Research Center's Digital Video Facility. [2] Simulations were performed on three types of widescreen scanning patterns: (1) 525-line progressive scan, sampled at eight times color subcarrier (8xFSC, or 28.636 MHz), (2) 1050-line 2:1 interlaced, sampled at 8xFSC, and (3) 1125-line 2:1 interlaced, sampled at 910 times the line rate (30.7125 MHz). The 525-line signal has 480 active picture lines per frame, and the 1050- and 1125-line signals have 960 active lines per frame.

At an early stage in the processing, the high line-rate signals are converted to standard 525-line interlaced signals, which are processed at a 4xFSC rate. The reconstructed widescreen signals are processed at the initial sampling rate.

Important issues yet to be addressed include the effects of noise in the transmission channel and imperfect regeneration of the auxiliary subcarrier. Future simulations will study the impact of noise, multipath, and other degradations on the quality of the reconstructed widescreen picture.

A variety of widescreen source material was used. Many still images, including natural imagery and resolution charts, were processed and analyzed for static artifacts. Several motion sequences, ranging from one-half to twelve seconds in duration, were also processed and analyzed for motion artifacts. (Each second of video takes eight hours to process!) The artifacts are described in a later section.

The processed sequences (44 fields at a time) may be viewed on high line rate monitors at the output of video memory. These sequences can also be spliced together and recorded by an HDTV VTR for demonstrations, as was done for this conference.

REFERENCES

[1] Y. Yasumoto, *et al.*, "An Extended Definition Television System Using Quadrature Modulation of the Video Carrier with Inverse Nyquist Filter", *IEEE Trans. Consumer Electronics*, CE-33, no. 3., Aug. 1987, 173-180.

[2] C.H. Strolle, *et al.*, "Digital Video Processing Facility with Motion Sequence Capability", *ICCE Digest of Technical Papers*, June 5-7, 1985, p. 178.

For further information, contact:

Jack S. Fuhrer
Director, Television Research Laboratory
David Sarnoff Research Center
Princeton, NJ 08540